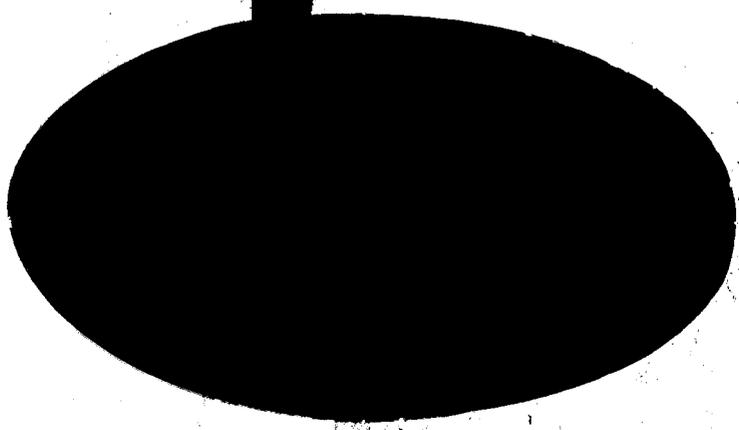


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APOLLO

GUIDANCE, NAVIGATION AND CONTROL

MASSACHUSETTS INSTITUTE OF TECHNOLOGY



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CAMBRIDGE MASSACHUSETTS 02139 LABORATORY

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GUIDANCE, NAVIGATION AND CONTROL

Submitted by: P. Rep. for M.H. Hamilton Date: 4-5-72
M. H. HAMILTON, DIRECTOR, MISSION PROGRAM DEVEL.
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: S. L. Copps Date: 4-5-72
S. L. COPPS, COLOSSUS PROJECT MANAGER
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: R. H. Battin Date: 4/5/72
R. H. BATTIN, DIRECTOR, MISSION DEVELOPMENT
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: D. G. Hoag Date: 5 Apr 72
D. G. HOAG, DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: R. R. Ragan Date: 6 Apr 72
R. R. RAGAN, DEPUTY DIRECTOR
CHARLES STARK DRAPER LABORATORY

R-577.

GUIDANCE SYSTEM OPERATIONS PLAN
FOR MANNED LM EARTH ORBITAL AND
LUNAR MISSIONS USING
PROGRAM COLOSSUS 3

SECTION 7 ERASABLE MEMORY PROGRAMS

April 1972

MIT

CAMBRIDGE, MASSACHUSETTS, 02139

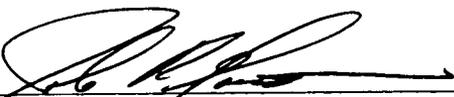
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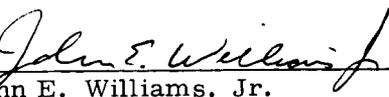
ACKNOWLEDGEMENT

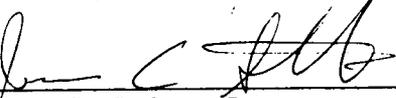
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GUIDANCE SYSTEM OPERATIONS PLAN
FOR MANNED LM EARTH ORBITAL
AND LUNAR MISSIONS
USING PROGRAM COLOSSUS 3
SECTION 7 ERASABLE MEMORY PROGRAMS

Signatures appearing on this page designate approval of this document by NASA/MSC.

Approved:  Date: 4/4/72
John R. Garman
Section Chief, Guidance Program Section
Manned Spacecraft Center, NASA

Approved:  Date: 4/4/72
John E. Williams, Jr.
Chief, Simulation and Flight Software Branch
Manned Spacecraft Center, NASA

Approved:  Date: 4/5/72
James C. Stokes, Jr.
Chief, Flight Support Division
Manned Spacecraft Center, NASA

<u>NO.</u>	<u>TITLE</u>
- - -	Introduction
EMP 500	Landmark Tracking With Datalink Failure Or Unusable Optics
EMP 501	Landmark Tracking With Failed Mark/Mark Rej Button
EMP 502	Software Restart
EMP 503	GDC REFSMMAT Determination
EMP 504	Backup Optics Variance
EMP 505	Mark Taking With Mark Button Failure
EMP 506	DSKY Display Of VHF Range During P79
EMP 508	Landmark Tracking With Frozen Optics
EMP 509	Inhibit Gimbal Lock Monitor Downmoding
EMP 512	P40/41/47 Termination During AverageG When EMP 509 Is Operating
EMP 514	Shortened P23
EMP 515	Manual Range Input
EMP 517	Convert Optics Shaft And Trunnion Angles To Body Angles
EMP 518	Recovery From Restart During Plane-Change Pulse Torquing
EMP 520	Entrance Into Minkey For Post-Plane-Change Pulse Torquing
EMP 521	Enter P51/P53 With IMU-Operate Bit Failed Off
EMP 522	SPS Gimbal Drive Test
EMP 523	Monitor Jet-On Failure

Note: The Erasable Memory Programs (EMP) contained in this section are individually paginated within each EMP.

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INTRODUCTION

GENERAL

Section 7 of the Guidance System Operations Plan (GSOP) describes erasable-memory programs (EMPs) designed for the guidance computers used in the command (CMC) and lunar modules (LGC). CMC programs are designated COLOSSUS 3, and the associated EMPs are identified by a three-digit number beginning with "5." LGC programs are designated LUMINARY 1E, and the associated EMPs are identified, with one exception, by a three-digit number beginning with "1." The exception is EMP 99.

The EMPs vary in complexity from a simple flagbit setting to a long and intricate logical structure. They all, however, cause the computer to behave in a way not intended in the original design of the programs; they accomplish this off-nominal behavior by some alteration of erasable memory to interface with existing fixed-memory programs to effect a desired result.

CAUTION.—Great care must be taken when loading or performing an EMP. An erroneous digit loaded into NOUN 26, for example, could cause indeterminate operation upon program initiation.

NOTE 1.—The EMPs described in this section should not be run simultaneously except when explicitly specified.

NOTE 2.—Level 6 performance-evaluation testing has not been performed on EMPs.

The following format is used throughout this section:

NUMBER AND NAME OF EMP.

PURPOSE.

FUNCTIONAL DESCRIPTION—a brief description of the EMP and how it interfaces with fixed-memory programs (may include a functional-flow diagram).

ASSUMPTIONS—prerequisite conditions and configurations.

RESTRICTIONS AND LIMITATIONS—conditions and operations that would interfere with, or be affected by, the EMP.

PROCEDURES—instructions for performing the EMP.

RECOVERY/TERMINATION—procedures for terminating the EMP or recovering from a hardware or software restart.

ERASABLE MEMORY—listing of memory locations (octal) and the code (mnemonic and octal) comprised by the EMP.

UPLINK—P27 format for loading the EMP into erasable memory.

JOBS AND TASKS

A number of EMPs are initiated by VERB 30 ENTR (Request Executive) or VERB 31 ENTR (Request WAITLIST). When the EMP is programed as a JOB, the activation procedures specify VERB 30 ENTR; when the EMP is programed as a TASK, the procedures specify VERB 31 ENTR. The distinction is on the basis of how the program is dispatched. A JOB carries a priority; when the JOB's priority comes up on the executive queue, the JOB is activated. A TASK differs in that it is performed as a T3-clock interrupt. The AGC WAITLIST program sets the T3 clock to overflow at a specified time; when the overflow occurs, other program activity is interrupted, and the TASK is performed.

For VERB 30 use, the JOB's priority is specified in R1 of NOUN 26. R1 of NOUN 26 also contains in the low-order digit an indication of whether or not the JOB is to be assigned a VAC area: if the low-order digit is "1," a VAC area is reserved for the JOB; if it is "0," no VAC area is reserved.

For VERB 31 use, R1 of NOUN 26 must contain the time specified to elapse (in centiseconds) between the keying of ENTR (after VERB 31) and TASK execution.

EMPs activated by VERB 30 ENTR (i.e., JOB EMPs) require NOUN 26 to be loaded as follows:

$R1 = xx00y_8$

where

$xx_8 = \text{JOB Priority}$

$y = 1$ designates a VAC JOB;

$y = 0$ designates a NOVAC JOB.

$R2 = xxxxx_8$

where

$xxxxx_8$ is the JOB starting address

R3 = xxxxx₈

where

xxxxx₈ is the BBCON, containing the fixed, super, and erasable banks associated with the JOB

EMPs activated by VERB 31 ENTR (i.e., TASK EMPs) require NOUN 26 to be loaded as for a JOB EMP, except that R1 contain not a JOB priority, but a time delay as described above:

R1 = xxxxx₈ cs delay

R2 = xxxxx₈ starting address

R3 = xxxxx₈ BBCON

The BBCON is packed as follows:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	Octal F-bank						Octal S-bank						Octal E-bank		

F-banks 00-27₈ are addressed independently of S-bank contents; F-banks 30-37₈ are addressed for S-bank values of 3₈ or less, and F-banks 40-43₈ are addressed for an S-bank value of 4₈:

Example 1

BBCON = 66107₈

F-bank 33	}	F-bank 43 ₈
S-bank 4		
E-bank 7		

Example 2

BBCON = 66063₈

F-bank 33	}	F-bank 33 ₈
S-bank 3		
E-bank 3		

Example 3

BBCON = 02006₈

F-bank 01
S-bank unnecessary
E-bank 6

DOWNLINK

Listed below are the EMPs and the particular downlist transmitted during the operation of each EMP:

COLOSSUS

<u>EMP</u>		<u>Downlist</u>
500		P22 List
501		P22 List
502		Any
503		Coast and Align List
504		Rendezvous and Prethrust List
505	P20/P23	Rendezvous and Prethrust List
	P22/P24	P22 List
	P5X	Coast and Align List
506		Rendezvous and Prethrust List
508		P22 List
509		Any
512		Powered List, Coast and Align List
513		Entry and Update List
514		Rendezvous and Prethrust List
515		Rendezvous and Prethrust List
517		Coast and Align List
518		Coast and Align List, Entry and Update List (during P27)
520		Rendezvous and Prethrust List, Coast and Align List
521		Coast and Align List
522		Any but Powered
523		Any but Powered

LUMINARY

EMP

Downlist

99	Orbital Maneuvers List
100A & 100B	Any
101	Orbital Maneuvers List
102	Any
103A & 103B	Descent and Ascent List
104	Rendezvous and Prethrust List
106	Coast and Align List, Lunar Surface Align List
107	Descent and Ascent List
108	Any

EMP 500: LANDMARK TRACKING WITH DATALINK
FAILURE OR UNUSABLE OPTICS

PURPOSE:

EMP 500 provides a means of P24 mark taking with the COAS when the OSS is totally unusable or with the optics when the only failure is in the datalink between optics and CMC.

NOTE.—If the optics are mechanically immobile ("frozen") but otherwise operational (good CDUs), use EMP 508. If optics are operational except for failed MARK or MARK REJ button, use EMP 501 or EMP 505.

FUNCTIONAL
DESCRIPTION:

Certain flags, erasables, and nouns are changed (see PROCEDURES) to cause P24/R52 to enable the Tracking Attitude Routine (R61). R61 points a specified body axis (NOUN 78) at a landmark vector specified in RLS.

EMP 500 is started by VERB 30 ENTR. A PRO response to FL VERB 53 initiates the MARK function. MARK time, inertial CDU angles, and fixed optics angles are stored in temporary registers. The optics angles are obtained from NOUN 94, loaded manually at the start of P24. The existing fixed-memory task MARKCONT is then set up to store the mark data on the downlink and to set certain flags and counters as in a normal MARK.

The MARK REJ function is initiated by an ENTR response to FL VERB 53. Here, EMP 500 code is the same as the normal P24 MARK REJ code.

VERB 34 ENTR response to FL VERB 53 terminates EMP 500, which returns FL VERB 51 in P24. (See RECOVERY/TERMINATION.)

ASSUMPTIONS:

EMP 500 is called (see PROCEDURES) when—

1. Either the optics are totally unusable or a datalink failure between optics and CMC has occurred (bad CDUs).

2. Program coding has been uplinked via P27 (see ERASABLE MEMORY and UPLINK).
3. If optics are totally unusable, COAS calibration has been performed.
4. P20 is not running.

RESTRICTIONS
AND LIMITATIONS:

1. The following programs must not be operated between the time EMP 500 coding is uplinked and the time the program is initiated: P21, P22, P23, P29, P3x, P4x, P5x, P6x, P7x.
2. No optics positioning capability. (Use RHC to center landmark in COAS; use MIC to center landmark in SCT —failed datalink.)
3. Step 1 of PROCEDURES, used to initiate tracking in P24, requires that P24 be exited via VERB 37 ENTR xx ENTR rather than by the normal PRO on FL VERB 51. (See RECOVERY/TERMINATION.)
4. Use of the RHC terminates automatic tracking. (See PROCEDURES.)
5. A restart causes possibly erroneous automatic tracking. (See RECOVERY/TERMINATION.)
6. EMP 500 was designed for high-altitude use only.

PROCEDURES:

1. The following preliminary procedures should be accomplished at the FL VERB 06 NOUN 89 display in P24:
 - a. Place OPT MODE switch in CMC
 - b. Place OPT ZERO switch in ZERO
 - c. Load/verify RLS (E-memory address 2025-2032) valid for landmark
 - d. Load NOUN 78 as follows:
 - 1) COAS (Optics unusable)
Key—
VERB 25 NOUN 78 ENTR
+ENTR (R1, +000.00 deg, ν)
+ENTR (R2, +000.00 deg, ρ)
+ENTR (R3, +000.00 deg, OMICRON)

or

2) SCT (datalink failed)

Key—

VERB 25 NOUN 78 ENTR

+xxxxx ENTR } nearest 0.01 deg
+xxxxx ENTR } Voiced from ground
+xxxxx ENTR }

e. Load NOUN 79 (R2) with 0.5-deg deadband:

Key—

VERB 22 NOUN 79 ENTR

+50 ENTR

f. Load NOUN 94 as follows:

1) COAS

key—

VERB 24 NOUN 94 ENTR

+ ENTR (R1, 000.00 deg, shaft)

+57470 ENTR (R2, +57.470 deg, trunnion)

NOTE.—The actual values loaded here should be those obtained by the COAS calibration procedure.

or

2) SCT

key—

VERB 24 NOUN 94 ENTR

+xxxxx ENTR (R1, nearest 0.01 deg, TPAC shaft)

+xxxxx ENTR (R2, nearest 0.001 deg, TPAC trunnion)

2. Upon FL VERB 51 in P24,

a) key—

VERB 21 NOUN 1 ENTR

3374 ENTR

ENTR

to zero R61CNTR;

b) key VERB 44 ENTR to set SURFFLAG (FLAGWRD8, BIT 8).

c) key—

VERB 1 NOUN 1 ENTR

107 ENTR

to observe condition of AZIMFLAG (FLGWRD11, BIT 8). If set, three-axis maneuver will be performed in R61. If cleared, a VECPOINT maneuver will be performed in R61. To change AZIMFLAG, key—

VERB 25 NOUN 7 ENTR

107 ENTR

200 ENTR

x ENTR (where x = 1 for three-axis maneuver; x = 0 for VECPOINT maneuver)

d) key—

VERB 25 NOUN 7 ENTR

75 ENTR

1020 ENTR

1 ENTR

to set TARG1FLG (FLAGWRD1, BIT 10) and TRACKFLG (FLAGWRD1, BIT 5)

3. Perform automatic maneuver to tracking attitude
4. Observe FL VERB 51 ("Please MARK")
5. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 500:

R1 14000

R2 01603

R3 16067

6. Key VERB 30 ENTR to call EMP 500
7. Upon FL VERB 53 ("Please mark alternate LOS"), place CMC MODE switch in FREE, and

a) use RHC to center LMK in COAS, or

b) use MIC to center LMK in SCT (for failed datalink).

NOTE.—Use of RHC terminates automatic tracking. To reestablish, use normal P20 techniques (CMC AUTO, VERB 58 ENTR).

8. Key PRO to mark (to reject mark, key ENTR)
9. To exit EMP 500, key VERB 34 ENTR
10. To exit EMP 500 and P24, key—
VERB 37 ENTR xx ENTR
VERB 45 ENTR (to reset SURFFLAG, if desired).

RECOVERY/
TERMINATION:

1. EMP 500 is not restart protected. A restart during its operation results in a blank DSKY, except for "24" in the PROG registers, and possibly erroneous tracking. To recover from a restart perform the following:

- a. Key VERB 37 ENTR 24 ENTR.

NOTE.—Any previous MARKs on downlist will be lost, i.e., zeroed by P24.

- b. At FL VERB 51, redo steps 2a, 2d, and, if necessary, 3 under PROCEDURES.
- c. At FL VERB 51, key VERB 30 ENTR to initiate EMP.

2. P24 should be exited by VERB 37 ENTR xx ENTR. (PRO response to FL VERB 51 does not effect normal exit.) Calling another program (Pxx) also restores flags specially configured by preliminary procedures —except SURFFLAG, which is reset by keying VERB 45 ENTR, if desired.

ERASABLE
MEMORY:

Program coding for EMP 500 is as follows:

<u>ECADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>
1016	N26/PRI	OCT	14000
1017		OCT	01603
1020		OCT	16067
3603	P24BKUP	CA	V53
3604		TC	BANKCALL
3605		CADR	E/BKCALL
3606		CADR	GOMARKF
3607		TC	MKVB5X
3610		TC	+2
3611		TC	P24REJ
3612		INHINT	
3613		CA	MRKBUF1 +3
3614		TS	MKCDUS
3615		CA	MRKBUF1 +5
3616		TS	MKCDUT
3617		CA	CDUY
3620		TS	MKCDUY
3621		CA	CDUZ
3622		TS	MKCDUZ
3623		CA	CDUX
3624		TS	MKCDUX
3625		EXTEND	
3626		DCA	TIME2
3627		DXCH	MKT2T1
3630		CA	ONE
3631		TC	TWIDDLE
3632		ADRES	MARKCONT
3633		TC	P24BKUP
3634	P24REJ	CS	FLAGWRD1
3635		MASK	MARKBIT
3636		CCS	A
3637		TC	P24BKUP
3640		TC	DOWNFLAG
3641		ADRES	MARKFLAG
3642		TC	DOWNFLAG
3643		ADRES	P24MKFLG
3644		CCS	P22DEX
3645		TC	+3
3646		CA	OCT34
3647		TC	+3
3650		CS	SEVEN
3651		AD	P22DEX
3652		TS	MPAC
3653		EXTEND	
3654		INDEX	MPAC
3655		DCS	SVMRKDAT
3656		INDEX	MPAC
3657		DXCH	SVMRKDAT
3660		TC	P24BKUP
3661	V53	VN	5300

UPLINK:

P27 uplink for loading CMC erasable memory for EMP 500
is as follows:

<u>Load 1</u>	<u>Load 2</u>	<u>Load 3</u>	<u>Load 4</u>
V71E	V71E	V71E	V71E
5E	24E	24E	15E
1016E	3603E	3625E	3647E
14000E	31661E	6E	1652E
1603E	4636E	30025E	44774E
16067E	26036E	52355E	61753E
V33E	20576E	34770E	54154E
	2052E	5223E	6E
	1612E	2204E	50154E
	1634E	1603E	41540E
	4E	40075E	50154E
	31725E	74765E	53540E
	54357E	10000E	1603E
	31727E	1603E	15200E
	54361E	5561E	V33E
	30033E	32E	
	54356E	5561E	
	30034E	52E	
	54360E	11753E	
	30032E	1650E	
	54362E	34172E	
	V33E	V33E	

EMP 501: LANDMARK TRACKING WITH
FAILED MARK/MARK REJ BUTTON

PURPOSE: EMP 501 provides a means of using the DSKY PRO/ENTR keys for P24 mark taking when the optics MARK/MARK REJ button(s) are the only OSS malfunction.

NOTE1.—If the optics are mechanically immobile ("frozen") but otherwise operational (good CDUs), use EMP 508. If OSS is totally unusable or if there is a failure in the datalink between the optics and the CMC, use EMP 500.

NOTE2.—EMP 501 can be replaced by EMP 505.

FUNCTIONAL
DESCRIPTION:

Normal P24 landmark tracking procedures (P20, option 2, then P24) are completed through the FL VERB 51 display. At this point, EMP 501 is called via VERB 30 ENTR. A FL VERB 53 is displayed. A PRO on this display will initiate the MARK function. The mark time, inertial CDUs and optics CDUs are stored in temporary registers. The existing fixed memory task MARKCONT is set up to store the mark on the downlink and set certain flags and counters as in a normal MARK. The FL VERB 53 is then redisplayed.

An ENTR response to the FL VERB 53 display will initiate the MARK REJ function. Here, EMP 501 code is the same as the normal P24 MARK REJ code. The FL VERB 53 is then redisplayed.

EMP 501 is terminated via VERB 34 ENTR, redisplaying FL VERB 51 in P24 via the fixed memory code at MKVB5X. (See RECOVERY/TERMINATION.)

ASSUMPTIONS:

1. A failure has occurred in the MARK or MARK REJ button. All other optics functions are working properly.
2. Program coding has been uplinked via P27. (See ERASABLE MEMORY and UPLINK.)

RESTRICTIONS

AND LIMITATIONS:

The following programs must not be operated between the time EMP 501 coding is uplinked and the time the program is initiated: P21, P22, P23, P29, P3x, P4x, P5x, P6x, P7x.

PROCEDURES:

1. Normal landmark tracking procedures (P20, option 2, then P24) are completed through the FL VERB 51 ("Please MARK") display.
2. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 501:
R1 14000
R2 01603
R3 16067
3. Key VERB 30 ENTR to call EMP 501.
4. Upon FL VERB 53 ("Please mark alternate LOS"), use OHC to center LMK in optics.
5. Key PRO to mark (to reject mark, key ENTR).
6. To exit EMP 501, key VERB 34 ENTR (FL VERB 51 returns). (To exit EMP 501 and P24, key VERB 37 ENTR xx ENTR.)

RECOVERY/
TERMINATION:

1. EMP 501 is not restart protected. Therefore, the EMP must be reestablished after a restart via VERB 30 ENTR. Because of the restart in P24, the PROG Alarm Light will be on (120 alarm—"Optics torque request with optics not zeroed"). Therefore, the optics must be zeroed again and the landmark reacquired before more marks can be made.

NOTE.—Since driving of the optics occurs even with the alarm, zeroing of the optics can be omitted if the CDUs can be shown to be valid, (e.g., by comparing NOUN 91 with the TPAC).

During a restart in P24, the Sighting Mark Routine (R53) is restarted. Therefore, any marks taken after the restart will overwrite those taken before.

2. EMP 501 is terminated by VERB 34 ENTR, redisplaying FL VERB 51 in P24. P24 can be terminated normally. (PRO on FL VERB 51). (EMP 501 and P24 can be exited directly by VERB 37 ENTR xx ENTR.)

ERASABLE
MEMORY:

Program coding for EMP 501 is as follows:

<u>EC ADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>	
1016	N26/PRI	OCT	14000	14000
1017		OCT	01603	01603
1020		OCT	16067	16067
3603	P24BKUP	CA	V53	31661
3604		TC	BANKCALL	04636
3605		CADR	E/BKCALL	26036
3606		CADR	GOMARKF	20576
3607		TC	MKVB5X	02052
3610		TC	+2	01612
3611		TC	P24REJ	01634
3612		INHINT		00004
3613		CA	CDUS	30036
3614		TS	MKCDUS	54357
3615		CA	CDUT	30035
3616		TS	MKCDUT	54361
3617		CA	CDUY	30033
3620		TS	MKCDUY	54356
3621		CA	CDUZ	30034
3622		TS	MKCDUZ	54360
3623		CA	CDUX	30032
3624		TS	MKCDUX	54362
3625		EXTEND		00006
3626		DCA	TIME2	30025
3627		DXCH	MKT2T1	52355
3630		CA	ONE	34770
3631		TC	TWIDDLE	05223
3632		ADRES	MARKCONT	02204
3633		TC	P24BKUP	01603
3634	P24REJ	CS	FLAGWRD1	40075
3635		MASK	MARKBIT	74765
3636		CCS	A	10000
3637		TC	P24BKUP	01603
3640		TC	DOWNFLAG	05561
3641		ADRES	MARKFLAG	00032
3642		TC	DOWNFLAG	05561
3643		ADRES	P24MKFLG	00052
3644		CCS	P22DEX	11753
3645		TC	+3	01650
3646		CA	OCT34	34172
3647		TC	+3	01652
3650		CS	SEVEN	44774
3651		AD	P22DEX	61753
3652		TS	MPAC	54154
3653		EXTEND		00006
3654		INDEX	MPAC	50154
3655		DCS	SVMRKDAT	41540
3656		INDEX	MPAC	50154
3657		DXCH	SVMRKDAT	53540
3660		TC	P24BKUP	01603
3661	V53	VN	5300	15200

UPLINK:

P27 uplink for loading CMC erasable memory for EMP 501
is as follows:

<u>Load 1</u>	<u>Load 2</u>	<u>Load 3</u>	<u>Load 4</u>
V71E	V71E	V71E	V71E
5E	24E	24E	15E
1016E	3603E	3625E	3647E
14000E	31661E	6E	1652E
1603E	4636E	30025E	44774E
16067E	26036E	52355E	61753E
V33E	20576E	34770E	54154E
	2052E	5223E	6E
	1612E	2204E	50154E
	1634E	1603E	41540E
	4E	40075E	50154E
	30036E	74765E	53540E
	54357E	10000E	1603E
	30035E	1603E	15200E
	54361E	5561E	V33E
	30033E	32E	
	54356E	5561E	
	30034E	52E	
	54360E	11753E	
	30032E	1650E	
	54362E	34172E	
	V33E	V33E	

EMP 502: SOFTWARE RESTART

PURPOSE: EMP 502 provides a means of causing a software restart by keying VERB 31 ENTR.

FUNCTIONAL DESCRIPTION: EMP 502 uses existing fixed program code to perform BAILOUT and store Alarm Code 31211.

ASSUMPTIONS: NA

RESTRICTIONS AND LIMITATIONS: NA

- PROCEDURES:
1. Key—
VERB 25 NOUN 26 ENTR
1 ENTR
2071 ENTR } fixed-memory address of MKABORT
16000 ENTR }
 2. To effect software restart, key VERB 31 ENTR
 3. Observe PROG alarm light
 4. Key VERB 5 NOUN 9 ENTR to observe alarm code 31211, "Illegal interrupt of extended verb"
 5. Key RSET to clear alarm

RECOVERY/
TERMINATION: NA

ERASABLE
MEMORY: NA

UPLINK: NA

EMP 503: GDC REFSMMAT DETERMINATION

PURPOSE: EMP 503 provides a means of using the gyro display coupler (GDC) to determine orientation of the spacecraft. This program establishes the inertial reference for performing rendezvous with an unusable IMU.

NOTE1.—EMP 503 complements EMP 504 and 506 for performing rendezvous navigation with a failed IMU.

NOTE2.—To perform REFSMMAT determination with the IMU-OPERATE discrete failed off, use EMP 521.

FUNCTIONAL DESCRIPTION: EMP 503 bypasses only the very first part of P51/P53 (see Figure: EMP 503), that part which determines whether the IMU is on and operating (bit 9 of IMODES30).

ASSUMPTIONS:

1. GDC is inertial
2. IMU is unusable

RESTRICTIONS AND LIMITATIONS: Inertial reference established by EMP 503 is valid for only one spacecraft orientation, i.e., the orientation of the spacecraft when the two P51/P53 star sightings are made: the same orientation must be maintained during rendezvous sightings.

PROCEDURES: To initiate EMP 503, perform the following:

1. Preliminary
 - a. Key VERB 96 ENTR to clear all program activity.
 - b. To set MODREG to decimal 51, key—
VERB 21 NOUN 1 ENTR
1214 ENTR
63 ENTR
to set MODREG to decimal 53, key—
VERB 21 NOUN 1 ENTR
1214 ENTR
65 ENTR

c. Key—

VERB 25 NOUN 26 ENTR

13001 ENTR

3425 ENTR

30005 ENTR } fixed-memory address

of P51AA

to set up for the call to P51/P53 bypassing
IMU-on check.

2. Activate

- a. Key VERB 30 ENTR to start EMP 503 (and
P51/P53)

NOTE.—If it is desired that the
REFSMMAT calculated by P51/P53
approximate a valid GDC inertial-
attitude description, key VERB 25
and load NOUN 20 as follows (before
step 2b):

Key—

VERB 25 NOUN 20 ENTR

±xxxxxx ENTR

±xxxxxx ENTR

±xxxxxx ENTR

where

R1 = GDC OGA to nearest 0.01 deg,

R2 = GDC IGA to nearest 0.01 deg,

R3 = GDC MGA to nearest 0.01 deg.

- b. Perform normal P51/P53 star sightings and
procedure, maintaining a fixed attitude

NOTE.—P51/P53 is activated when
VERB 30 is selected in step 2a, but
the mode lights will remain at 00
rather than displaying 51/53.

RECOVERY/
TERMINATION:

Normal P51/P53 restart and termination procedures.

ERASABLE
MEMORY:

NA

UPLINK:

NA

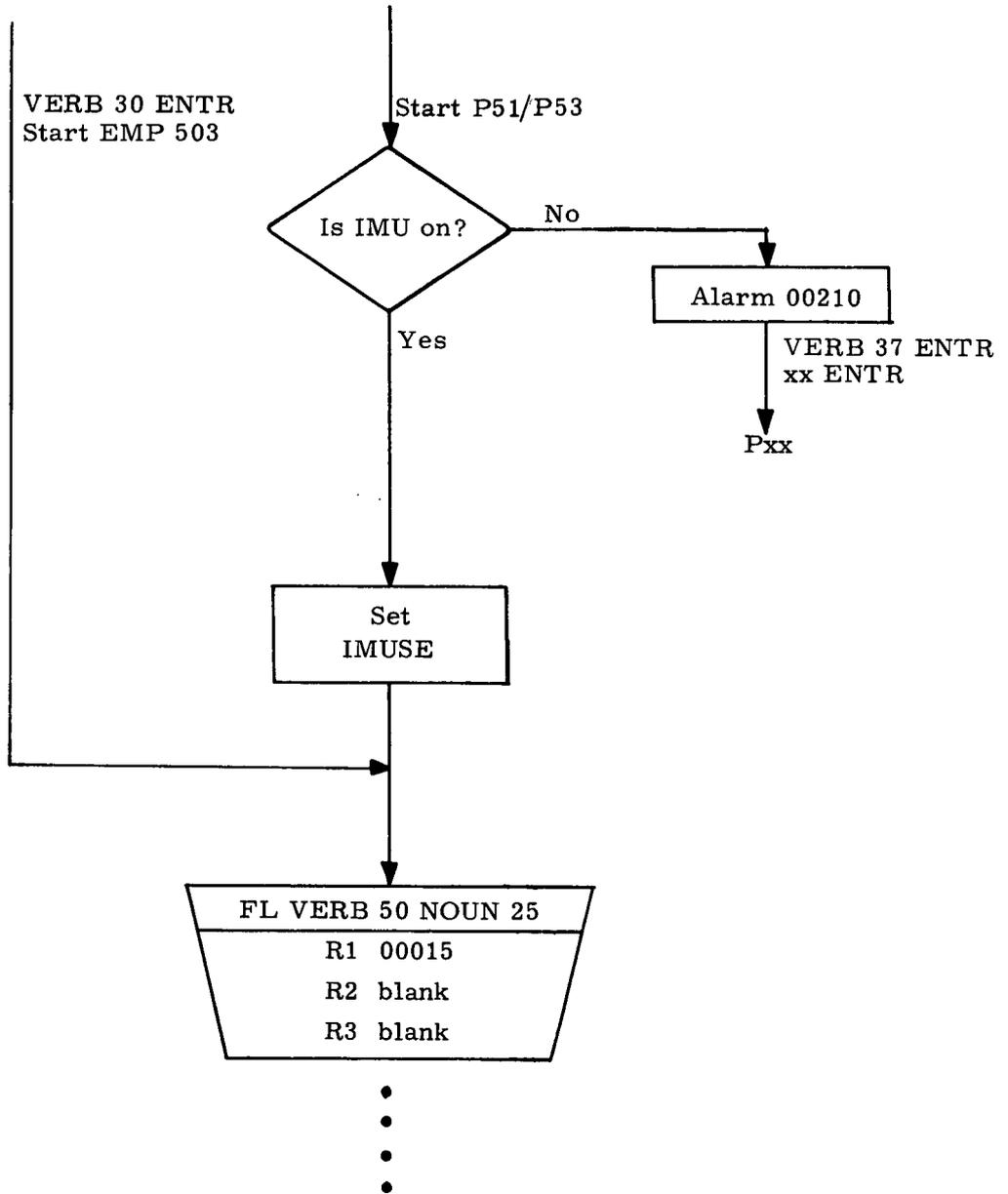


FIG: EMP 503

EMP 504: BACKUP OPTICS VARIANCE

PURPOSE: EMP 504 provides a means of using ALTVAR in place of SXTVAR in R22.

FUNCTIONAL DESCRIPTION:

EMP 504 is used to compensate for increased uncertainty when processing optics data obtained with a degraded ISS or OSS. This procedure utilizes the erasable variable ALTVAR instead of the fixed memory SXTVAR as the a-priori estimate for the angular error variance per axis.

NOTE.—EMP 504 complements EMPs 503 and 506 for performing rendezvous navigation with a failed IMU.

ASSUMPTIONS:

1. SXT or SCT usable—may be immobile (if good IMU)
2. Good OCDUs
3. Good MARK button

RESTRICTIONS AND LIMITATIONS:

If EMP 504 is being used as complementary program to EMP 503 (failed IMU), spacecraft attitude during marking must be the same as that used in EMP 503 to establish inertial reference.

PROCEDURES:

1. If REFSMFLG (FLAGWRD3, BIT 13) is not set, key—
VERB 25 NOUN 7 ENTR
77 ENTR
10000 ENTR
1 ENTR
to set REFSMFLG and enable selection of P20.
2. In P20, key—
 - a. VERB 25 NOUN 7 ENTR
76 ENTR
20000 ENTR
ENTR
to clear R21MARK (FLAGWRD2, BIT 14)
 - b. VERB 21 NOUN 1 ENTR
301 ENTR
37777 ENTR

to set MARKINDX to POSMAX

- c. VERB 21 NOUN 1 ENTR
1336 ENTR
31264 ENTR

to load OPTCADR with fixed-memory address of
ENDPLAC +1.

- 3. Use normal P20 marking procedures.

NOTE.—MARK REJ will cause FL VERB 51 to appear. To clear FL VERB 51, key PRO. (VERB 86 ENTR can be used in place of MARK REJ to avoid causing FL VERB 51.)

RECOVERY/
TERMINATION:

- 1. Any VERB 37 ENTR xx ENTR or
VERB 25 NOUN 7 ENTR
76 ENTR
20000 ENTR
1 ENTR (sets R21MARK—FLAGWRD2, BIT 14).
- 2. Any VERB 37 ENTR xx ENTR or restart disables
program. To reenale, repeat PROCEDURES.

ERASABLE
MEMORY:

See PROCEDURES

UPLINK:

NA

EMP 505: MARK TAKING WITH MARK BUTTON FAILURE

PURPOSE: EMP 505 provides a general-purpose mark taking routine for use when the MARK button has failed.

FUNCTIONAL DESCRIPTION: Normal program procedures are completed up to point when marking normally takes place (FL VERB 51, FL VERB 59, or P20 option 0 or 4). A VERB 31 ENTR will initiate the MARK function. The existing fixed-memory task MARKDIF is set up, and program operation will continue as if a normal mark had been taken.

ASSUMPTIONS: EMP 505 is called when (see PROCEDURES) failure has occurred in the MARK button and all other optics functions are working properly.

RESTRICTIONS AND LIMITATIONS:

1. If the MARK or MARK REJ button has failed intermittently on, then neither regular marking nor execution of EMP 505 can be relied on.
2. Refer to the following matrix for EMP 505 contingencies under combination MARK/MARK REJ fail conditions:

	MARK REJ Button Failed Off	MARK REJ Button Failed On
MARK Button Failed Off	Use EMP 505 from NAV DSKY	EMP 505 cannot be used
MARK Button Failed On	Follow PROCEDURES Step 1 on the MAIN DSKY. Then depress any key on the NAV DSKY to effect a mark.	Follow PROCEDURES Step 1 on the MAIN DSKY. Then depress any key on the NAV DSKY to effect a mark.

PROCEDURES: 1. Perform normal program procedures up to point when marking normally takes place (FL VERB 51, FL VERB 59, or P20 option 0 or 4).

2. Load NOUN 26 as follows:
Key VERB 25 NOUN 26 ENTR

1 ENTR	}	fixed-memory address of MARKDIF
2165 ENTR		
16067 ENTR		

NOTE.—The CDU transient-detection test (121g PROG alarm) is less effective in EMP 505 than in normal marking.

3. Key VERB 31 ENTR to take mark. (The ENTR accomplishes the MARK.)

NOTE1.—Unless a monitor display is active or any new display is initiated by the program or crew, the VERB 31 will remain in the VERB lights. (A KEY REL will reestablish the program display, if any.) As long as VERB 31 is in the VERB lights, an ENTR will activate EMP 505 to accomplish a mark. If VERB 31 is not in the VERB lights, Step 3 must be repeated if a mark is desired.

NOTE2.—Normal MARK REJ procedures apply when EMP 505 is operating, subject to noted exceptions.

4. When marking has been completed, continue with normal procedures for the program in use.

RECOVERY/
TERMINATION:

1. Normal restart procedures apply.
2. Terminate marking program normally after keying KEY REL, if necessary, to reestablish program display.

ERASABLE
MEMORY:

NA

UPLINK:

NA

EMP 506: DSKY DISPLAY OF VHF RANGE DURING P79

PURPOSE: EMP 506 provides a means of displaying VHF range on the DSKY during Final Rendezvous Program (P79).

NOTE.—EMP 506 complements EMPs 503 and 504 for performing rendezvous navigation with a failed IMU.

FUNCTIONAL
DESCRIPTION:

Setting UPDATFLG and enabling VHF ranging via VERB 87 ENTR during P20 option 0 or 4 enables VHF data processing in R22, thus allowing raw range data to be monitored.

ASSUMPTIONS:

1. P20 (option 0 or 4) operating
2. VHF locked on LM
3. CMC-computed range is less than 327.67 n.mi.
4. VHF ranging has been enabled via VERB 87 ENTR.

RESTRICTIONS
AND LIMITATIONS:

1. EMP 506 enables state-vector updates in R22. (P79 does not normally enable state-vector updates.)
2. Astronaut-loaded monitor display (see PROCEDURES) blocks a possible VERB 06 NOUN 49 display. A response to FL VERB 06 NOUN 49 is necessary for further updating of range display.
3. VHF range display updates only about once a minute (in conjunction with R22 processing of VHF range data).

PROCEDURES:

To initiate EMP 506—

1. Set UPDATFLG via—
VERB 25 NOUN 7 ENTR
75 ENTR
100 ENTR
1 ENTR
2. Key VERB 16 NOUN 2 ENTR
3703 ENTR
to initiate VHF range display.
3. Observe VHF range:
R1, xxx.xx n.mi.

NOTE.— If $R1 < 0$, range =
 $\frac{327.67}{|R1|}$.

RECOVERY/
TERMINATION:

1. To disable EMP 506,
 - a) reset UPDATFLG via—
VERB 25 NOUN 7 ENTR
75 ENTR
100 ENTR
ENTR
 - b) disable VHF ranging via—
VERB 88 ENTR.

2. To recover from a restart,
 - a) reselect P79 via—
VERB 37 ENTR 79 ENTR
 - b) repeat procedures.

ERASABLE
MEMORY:

NA

UPLINK:

NA

EMP 508: LANDMARK TRACKING WITH FROZEN OPTICS

PURPOSE: EMP 508 provides a means of using the SXT/SCT to track a landmark when the optics are immobile ("frozen") but otherwise operational (good CDUs).

NOTE.—For landmark tracking with totally unusable optics (COAS tracking), use EMP 500; for landmark tracking with failed MARK/MARK REJ button, use EMPs 501 or 505.

FUNCTIONAL DESCRIPTION: Certain flags, erasables, and nouns are changed (see PROCEDURES) to cause P24/R52 to enable the Tracking Attitude Routine (R61). R61 points the frozen LOS axis (manually loaded into NOUN 78) at a landmark vector specified in RLS.

Initial acquisition of the landmark is by the Attitude Maneuver Routine (R60). Then, the MIC is used to center the landmark in the optics. Normal MARK/MARK REJ procedures apply.

ASSUMPTIONS: P20 is not running.

RESTRICTIONS AND LIMITATIONS:

1. No optics positioning capability. (Use MIC to center landmark in optics.)
2. Step 1, used to initiate tracking in P24, requires that P24 be exited via VERB 37 ENTR xx ENTR rather than by the normal PRO on FL VERB 51. (See RECOVERY/TERMINATION.)
3. A restart causes possibly erroneous automatic tracking. (See RECOVERY/TERMINATION.)

PROCEDURES:

1. Before initiating frozen-optics tracking, perform the following at the FL VERB 06 NOUN 89 display in P24:
 - a. Place the OPT MODE switch in MAN
 - b. Place OPT ZERO switch to OFF
 - c. Verify that OCDUs are valid by comparing contents of NOUN 91 with TPAC. (If different, load NOUN 91 with TPAC numbers.)

- d. Load/verify RLS (E-memory address 2025-2032) valid for landmark
- e. Load NOUN 78 as follows, with values voiced from the ground:
Key—
VERB 25 NOUN 78 ENTR
+xxxxx ENTR (nearest 0.01 deg, λ)
+xxxxx ENTR (nearest 0.01 deg, ρ)
+xxxxx ENTR (nearest 0.01 deg, OMICRON)
- f. Load NOUN 79 (R2) with 0.5-deg deadband:
Key—
VERB 22 NOUN 79 ENTR
+50 ENTR
- g. Load NOUN 89 as follows:
Key—
VERB 25 NOUN 89 ENTR
 \pm xxxxx ENTR (nearest 0.001 deg, Lat)
 \pm xxxxx ENTR (nearest 0.001 deg, Long/2)
 \pm xxxxx ENTR (nearest 0.01 n.mi., altitude of LMK)

2. Upon FL VERB 51 in P24—

- a) Key VERB 21 NOUN 1 ENTR
3374 ENTR
ENTR
to zero R61CNTR
- b) Key VERB 44 ENTR to set SURFFLAG (FLAGWRD8, BIT 8)
- c) Key—
VERB 1 NOUN 1 ENTR
107 ENTR
to observe condition of AZIMFLAG (FLGWRD11, BIT 8). If set, three-axis maneuver will be performed in R61. If cleared, a VECPOINT maneuver will be performed in R61. To change AZIMFLAG, Key—
VERB 25 NOUN 7 ENTR
107 ENTR
200 ENTR
x ENTR (where x = 1 for three-axis maneuver; x = 0 for VECPOINT maneuver)

- d) Key—
VERB 25 NOUN 7 ENTR
75 ENTR
1020 ENTR
1 ENTR
to set TARG1FLG (FLAGWRD1, BIT 10) and
TRACKFLG (FLAGWRD1, BIT 5)

3. Perform automatic maneuver to tracking attitude
4. Upon FL VERB 51 ("Please MARK")—
- a. Place SC CONT switch in CMC
 - b. Place CMC MODE switch in FREE
 - c. Use MIC to center LMK in optics
 - d. Depress MARK button to take mark. (Depress MARK REJ to reject mark.)
 - e. To exit EMP 508 and P24, key VERB 37 ENTR xx ENTR. VERB 45 ENTR to reset SURFFLAG (if desired).

RECOVERY/
TERMINATION:

1. A restart will cause automatic tracking (R61) to be restarted incorrectly for use with EMP 508. Restart recovery is as follows:
- a. Key VERB 37 ENTR 24 ENTR
 - b. Verify that OCDUs are valid. (See step 1c under PROCEDURES.)
 - c. Redo steps 2a, 2d, and, if necessary, 3 under PROCEDURES.)
 - d. At FL VERB 51, continue marking.

NOTE1.—A restart during the operation of EMP 508 results in a blank DSKY. (P24 remains in PROG registers.) A PROG Alarm 120 ("Optics torque request with optics not zeroed") can be ignored, since OCDUs were verified in step b.

NOTE2.—OCDUs will not count back up to the frozen optics angles after zeroing.

2. P24 should be exited by VERB 37 ENTR xx ENTR. (PRO response to FL VERB 51 does not effect normal exit.) Calling another program (Pxx) also restores flags specially configured by preliminary procedures —except SURFFLAG, which is reset by keying VERB 45 ENTR, if desired.

ERASABLE
MEMORY: NA

UPLINK: NA

EMP 509: INHIBIT GIMBAL LOCK MONITOR DOWNMODING

PURPOSE: EMP 509 provides a means of inhibiting T4RUPT coarse alignment of the IMU when there is a runaway CDUZ.

FUNCTIONAL DESCRIPTION: EMP 509 causes GLOCKMON to believe program is in SATURN thrusting flight, bypassing downmoding of IMU into Coarse Align mode if $|\text{CDUZ}| > 85$ deg.

ASSUMPTIONS: NA

RESTRICTIONS AND LIMITATIONS:

1. R30 (VERB 82) data will refer to CSM at latest permanent state-vector time only.
2. Any VERB 37 ENTR xx ENTR while AVERAGEG is running (P1x, P4x, P6x) will disable EMP 509.
3. All translations will cause RCS DAP to use LM-on filter gains.

NOTE.—If CDU has failed, RCS DAP will not operate normally.

4. TVC DAP does not operate normally.
5. ENTRY programs do not operate normally (AVERAGEG will not be enabled).
6. VERB 46 should not be selected.
7. EMP 509 deactivates the automatic moding to coarse align at gimbal angles greater than 85 deg; maneuvering the vehicle into the area of a real gimbal lock will cause an IMU dump, with possible permanent damage to the IMU.

PROCEDURES: To initiate EMP 509—

1. Key VERB 48 ENTR and load NOUN 46 (R1) to 3xxxx.
2. Key VERB 34 ENTR to terminate R03 (do not key PRO).

3. Key-

VERB 25 NOUN 7 ENTR

75 ENTR

1 ENTR

1 ENTR

to set AVEGFLAG bit (FLAGWRD1, BIT 1).

NOTE.—This procedure will not inhibit the GIMBAL LOCK light from coming on.

RECOVERY/
TERMINATION:

To disable EMP 509—

1. Key VERB 48 ENTR and load NOUN 46 (R1) with desired configuration.
2. Reset AVEGFLAG bit as follows:

Key-

VERB 25 NOUN 7 ENTR

75 ENTR

1 ENTR

ENTR

ERASABLE
MEMORY:

NA

UPLINK:

NA

EMP 512: P40/41/47 TERMINATION DURING AVERAGEG
WHEN EMP 509 IS OPERATING

PURPOSE: EMP 512 allows P40/41/47 to be exited without causing a conflict with EMP 509, "Inhibit Gimbal Lock Monitor Downmoding."

FUNCTIONAL DESCRIPTION: The normal P40/41/47 exit resets AVEGFLAG, but EMP 509 requires this flag to be set. EMP 512, therefore, prevents the resetting of AVEGFLAG but otherwise allows correct termination of P40/41/47 and AVERAGEG. VERBS 93 (resets RENDWFLG and ORBWFLAG) and 44 (sets SURFFLAG) are used to prevent W-matrix and LM state-vector integration respectively. Since READACCS, which calls SERVICER, is still active while AVEGFLAG is set, these integration times would allow more SERVICERs to be called before completion of AVETOMID. A significant number of these could result in VAC or CORESET overflow. (See Figure: EMP 512.)

ASSUMPTIONS:

1. AVERAGEG is operating.
2. EMP 509 is operating.
3. Thrusting maneuver is controlled manually.

RESTRICTIONS AND LIMITATIONS:

1. See EMP 509 RESTRICTIONS AND LIMITATIONS.
2. After EMP 512 has been loaded (see UPLINK), Entry programs and P20, P22, and P23 mark incorporation are proscribed.
3. EMP 512 should not be selected during thrusting.
4. W-matrix will be invalid and will be reinitialized before next used.

PROCEDURES: Before ignition in P40 (do not PRO on FL VERB 99 NOUN 40) or after shutdown, at the FL VERB 16 NOUN 40, FL VERB 16 NOUN 85, or FL VERB 37, key—

NOTE.—In P41/47, perform Step 1 after AVERAGEG starts.

1. VERB 93 ENTR to reset RENDWFLG and ORBWFLAG.
2. VERB 44 ENTR (set SURFFLAG) to prevent LM state-vector integration.
3. VERB 5 NOUN 26 ENTR to verify data (see ERASABLE MEMORY):

R1 00001
R2 01520
R3 76067

4. VERB 31 ENTR to call EMP 512, which terminates AVERAGEG, updates the permanent state vector, and exits P40/41/47 to P00.
5. Observe 00 in PROG registers.
6. Key VERB 45 ENTR (reset SURFFLAG) to allow LM state-vector integration if desired.

RECOVERY/
TERMINATION:

EMP 512 is terminated and normal program flow reestablished as described under PROCEDURES. (See also RESTRICTIONS AND LIMITATIONS.)

Restarts

If PROG registers show new program, continue normal operation. If PROG registers still show 40/41/47, repeat procedures.

ERASABLE
MEMORY:

EMP 512 coding is as follows:

<u>ECADR</u>	<u>Tag</u>		<u>Code</u>	<u>Octal</u>
1016	N26/PRI	OCT	00001	00001
1017		2CADR	CHNGEXIT	01520
1020				76067
3520	CHNGEXIT	EXTEND		00006
3521		DCA	EXITCADR	31525
3522		DXCH	AVGEXIT	53062
3523		TCF	TASKOVER	15314
3524	EXITCADR	2CADR	EXITAVG	01526
3525				76067
3526	EXITAVG	CA	PRIO22	37644
3527		TC	PRIOCHNG	05176
3530		CA	ZERO	34772
3531		TS	MMNUMBER	55200
3532		TC	AVGEND	03100

UPLINK:

P27 uplink for loading CMC erasable memory for EMP 512
is as follows:

<u>Load 1</u>	<u>Load 2</u>
V 71 E	V 71 E
5 E	15 E
1016 E	3520 E
1 E	6 E
1520 E	31525 E
76067 E	53062 E
V33 E	15314 E
	1526 E
	76067 E
	37644 E
	5176 E
	34772 E
	55200 E
	3100 E
	V33 E

NOUN 26

1 csec
2CADR
CHNGEXIT

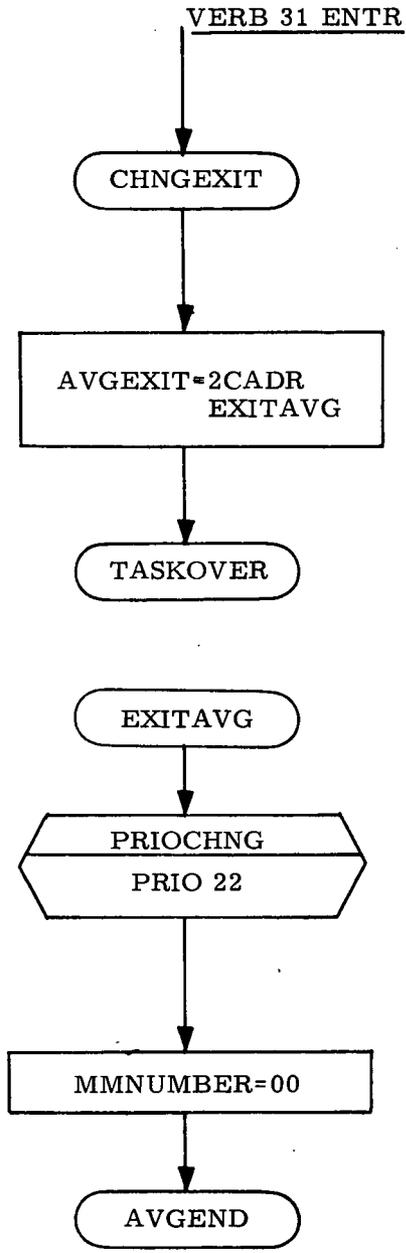


FIG: EMP 512

EMP 514: SHORTENED P23

PURPOSE: Bypassing certain unnecessary displays, EMP 514 allows time and keystrokes to be saved during consecutive marks, in P23, on the same star-horizon combination.

FUNCTIONAL DESCRIPTION:

For the first mark on a given star-horizon combination, the crew follows normal P23 procedures (mark calibration if necessary, automatic acquisition of star-horizon, etc.). Then, before calling P23 for the second mark, the crew calls EMP 514, which inverts the state of REFSMFLG and immediately exits.

A cleared REFSMFLG allows the Sighting Mark Routine (R53) to be called immediately upon the crew's next calling P23—bypassing the star-horizon acquisition maneuver. Marking and mark processing follow the normal pattern. After the final mark on a given star-horizon, the crew again calls EMP 514 to invert (i.e., to set) REFSMFLG and restore normal P23 sequencing.

ASSUMPTIONS:

1. Before first call:
 - a) REFSMFLG is set;
 - b) the optics are pointing at the specified star-horizon;
 - c) EMP 514 coding has been uplinked via P27. (See ERASABLE MEMORY and UPLINK.)
2. Before second call: the final mark for a given star-horizon has been taken and processed.

RESTRICTIONS AND LIMITATIONS:

1. With REFSMFLG cleared, any star-horizon acquisition must be done manually.
2. EMP 514 coding is nullified by the operation of P22, P32/P72, or P33/P73.

PROCEDURES:

1. For the first mark of a series of marks on a given star-horizon, perform normal P23 procedures except:
 - a. At the FL VERB 37 display following FL VERB 06 NOUN 49, key VERB 5 NOUN 26 ENTR and verify:

R1	10000
R2	01444
R3	14005
 - b. Key VERB 30 ENTR to call EMP 514, which resets REFSMFLG (FLAGWRD3, Bit 13) and exits.
 - c. Key KEY REL and observe return of FL VERB 37.
2. For the second mark on the same star-horizon, key 23 ENTR and observe immediate display of FL VERB 59.
3. Key in ENTR (assuming mark calibration has been done) and observe immediate display of FL VERB 51.
4. Proceed with normal procedures until all marks in the series have been taken and processed.
5. After the final mark on a given star-horizon, proceed to the end of P23; in response to FL VERB 37, key VERB 30 ENTR to call EMP 514, which now sets REFSMFLG and exits.
6. Key KEY REL and observe return of FL VERB 37. If marks are to be taken on a new star-horizon, repeat steps 1-5; otherwise, key xx ENTR, where xx is the desired CMC major mode. (See RESTRICTIONS AND LIMITATIONS.)
7. Key VERB 1 NOUN 1 ENTR 77 ENTR and verify that BIT 13 of R1 (REFSMFLG) is 1.

RECOVERY/
TERMINATION:

1. EMP 514 is not restart protected. Should a restart occur immediately after a VERB 30 ENTR, key VERB

1 NOUN 1 ENTR 77 ENTR and verify that BIT 13 of R1 (REFSMFLG) has the desired configuration (0 or 1). If not, key VERB 30 ENTR to recall EMP 514.

NOTE.— A restart occurring at the FL VERB 37 display in P23 results in a 21502 Alarm. To clear alarm, key RSET.

2. Because EMP 514 exits immediately after inverting REFSMFLG, no termination procedure is necessary other than to recall the program when finished marking on a given star-horizon.
3. Before calling another program after completing P23 mark taking, key—

VERB 1 NOUN 1 ENTR
77 ENTR

to check bit 13 of R1 (REFSMFLG) for the correct configuration (0 or 1).

ERASABLE
MEMORY:

Program coding for EMP 514 is as follows:

<u>ECADR</u>	<u>Tag</u>		<u>Code</u>	<u>Octal</u>
1016	N26/PRI	OCT	10000	10000
1017		OCT	01444	01444
1020		OCT	14005	14005
2444		TC	INTPRET	06006
2445		INVERT	EXIT	77414
2446			REFSMFLG	01562
2447		TC	ENDOFJOB	05205

UPLINK:

P27 uplink for loading CMC erasable memory for EMP 514
is as follows:

Either		Or
<u>Load 1</u>	<u>Load 2</u>	<u>Load 3</u>
V71E	V71E	V72E
5E	6E	17E
1016E	2444E	1016E
10000E	6006E	10000E
1444E	77414E	1017E
14005E	1562E	1444E
V33E	5205E	1020E
	V33E	14005E
		2444E
		6006E
		2445E
		77414E
		2446E
		1562E
		2447E
		5205E
		V33E

EMP 515: MANUAL RANGE INPUT

PURPOSE: EMP 515 provides a means to manually input range data into the CMC in the event of a VHF ranging problem.

FUNCTIONAL DESCRIPTION:

After VERB 88 ENTR is executed to inhibit R22 from reading the VHF range, a future value of range in nautical miles is loaded into location RM via VERB 21 NOUN 2 ENTR. When the actual range nears the value loaded into RM, VERB 30 is keyed. The ENTR key is depressed when the range loaded in RM is reached to execute EMP 515. The time the actual range is reached will be determined by a "MARK" voice cue from the LMP or by monitoring the EMS range counter contents.

EMP 515 clears REFSMFLG to terminate R22, stores current time in MARKTIME, delays 5.12 seconds to allow time for R22 to terminate, and then restarts R22 to process the mark data.

ASSUMPTIONS: VHF range data cannot be acquired automatically by the CMC.

RESTRICTIONS AND LIMITATIONS:

1. EMP 515 cannot be executed while R22 is processing a mark (optics or range).
2. Location 3703 cannot be reloaded until the last manual range mark is processed (Step 4 of PROCEDURES).
3. EMP 515 is overlaid by XSMD; therefore, the erasable program must be reloaded following the execution of P27, P40, P41, P52/P54 (options 2 or 4), or P52 for MINKEY plane change.

PROCEDURES:

1. Key VERB 88 ENTR to inhibit R22 VHF range processing.
2. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 515:

R1 26001
R2 00306
R3 70067

3. Wait for R22 to complete processing of last mark.
[NOUN 45 (R1) mark counter will be incremented when mark is incorporated.]
4. To load range into RM, key VERB 21 NOUN 2 ENTR
3703 ENTR
±xxxxx ENTR (xxx.xx n.mi., future value of range,
where $-163.83 \leq \text{xxx.xx} \leq +163.83$)

NOTE.—To load ranges between 163.83 n.mi. and 327.68 n.mi., a negative value of range, computed as follows, must be loaded:

Range (to be loaded) = Range
(actual) - 327.67 n.mi.

If the actual range is 327.67 n.mi.,
-0 must be loaded. Ranges greater
than 327.67 n.mi. cannot be used.

5. At a time prior to reaching the loaded range, key VERB 30.
6. At the time the actual range is reached, key ENTR to execute EMP 515.
7. To process another manual range mark, repeat steps 3-6.

RECOVERY/
TERMINATION:

EMP 515 is not restart protected. Depending upon where restart occurs, the following will result:

1. If R22 has started processing the mark, processing will continue normally.
2. If the restart occurs while REFSMFLG is off, P20 will terminate and the mark will be lost.

To reenable P20:

- a. Set REFSMFLG (FLAGWRD3, BIT 13), key—

VERB 25 NOUN 7 ENTR
77 ENTR
10000 ENTR
1 ENTR

- b. Reselect P20.

ERASABLE
MEMORY:

Program coding for EMP 515 is as follows:

<u>ECADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>	
1016	N26/PRI	OCT	26001	26001
1017		OCT	306	306
1020		OCT	70067	70067
306		EXTEND		00006
307		DCA	TIME2	30025
310		DXCH	MARKTIME	53062
311		TC	DOWNFLAG	05561
312		ADRES	REFSMFLG	00057
313		CAF	BIT10	34757
314		TC	BANKCALL	04636
315		CADR	E/BKCALL	26036
316		CADR	DELAYJOB	01731
317		TC	UPFLAG	05547
320		ADRES	REFSMFLG	00057
321		TC	RANGERD1	02742

UPLINK:

P27 uplink for loading CMC erasable memory for EMP 515
is as follows:

<u>Load 1</u>	<u>Load 2</u>
V71E	V71E
5E	16E
1016E	306E
26001E	6E
306E	30025E
70067E	53062E
V33E	5561E
	57E
	34757E
	4636E
	26036E
	1731E
	5547E
	57E
	2742E
	V33E

EMP 517: CONVERT OPTICS SHAFT
AND TRUNNION ANGLES TO BODY ANGLES

PURPOSE: In the event of immobile optics, EMP 517 provides a means of converting specified optics shaft and trunnion angles to equivalent body angles, which can be used for IMU realignments or for LM tracking in P20.

FUNCTIONAL DESCRIPTION: With the specified shaft and trunnion angles in NOUN 94, the crew calls EMP 517 (via VERB 30 ENTR), which computes the corresponding body angles, loads them into NOUN 78, and exits. This EMP performs the same function as the SKYLARK R64 routine.

ASSUMPTIONS: 1. NOUN 94 contains the specified optics shaft and trunnion angles
2. EMP 517 coding has been uplinked via P27. (See ERASABLE MEMORY and UPLINK.)

RESTRICTIONS AND LIMITATIONS: VERB 96 ENTR should be selected before EMP 517 is uplinked. Thereafter, programs and extended verbs should not be selected until operation of EMP 517 is completed.

PROCEDURES: 1. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 517:
R1 14001
R2 00605
R3 00000
2. Load NOUN 94 with specified shaft and trunnion angles:
Key—
VERB 24 NOUN 94 ENTR
+xxxxx ENTR (R1, +xxx.xx deg, shaft)
+xxxxx ENTR (R2, +xx.xxx deg, trunnion)
3. Key VERB 16 NOUN 78 ENTR to monitor computed body angles.
4. Key VERB 30 ENTR to call EMP 517; observe computed body angles in NOUN 78:

R1 ±xxx.xx deg gamma
R2 ±xxx.xx deg rho
R3 ±xxx.xx deg omicron

RECOVERY/
TERMINATION:

1. EMP 517 is not restart protected. If restart occurs during operation of EMP 517, FL VERB 37 will appear. Reinitiate via VERB 96 ENTR, VERB 30 ENTR.
2. EMP 517 is terminated upon completion of body angle computation.

ERASABLE
MEMORY:

Program coding for EMP 517 is as follows:

<u>ECADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>	
1016	N26/PRI	OCT	14001	14001
1017		OCT	00605	00605
1020		OCT	00000	00000
0604		OCT	00000	00000
0605		TC	INTPRET	06006
0606		AXC,1		77760
0607			MRKBUF1	03722
0610		RTB		77634
0611			E/CALL	26055
0612			SXTNB	46000
0613		STODL	COSTH	14021
0614			COSTH+4	00025
0615		ASIN	DCOMP	57536
0616		STORE	UTPIT	03740
0617		RTB		77634
0620			E/CALL	26055
0621			ARCTAN	26614
0622		STORE	UTYAW	03742
0623		EXIT		77776
0624		TC	ENDOFJOB	05205

UPLINK:

P27 uplink for loading CMC erasable memory for EMP 517
is as follows:

<u>Load 1</u>	<u>Load 2</u>
V71E	V71E
5E	23E
1016E	604E
14001E	E
605E	6006E
E	77760E
V33E	3722E
	77634E
	26055E
	46000E
	14021E
	25E
	57536E
	3740E
	77634E
	26055E
	26614E
	3742E
	77776E
	5205E
	V33E

EMP 518: RECOVERY FROM RESTART DURING
PLANE CHANGE PULSE TORQUING

PURPOSE:

EMP 518 provides a means of achieving the desired stable-member orientation and the associated REFSMMAT should a restart occur during the MINKEY plane-change pulse-torquing procedures. EMP 518 applies whether the restart occurs during pulse torquing before or after the PC maneuver. In addition to recovery from the restart, EMP 518 provides a means of obtaining a precise alignment following restart recovery.

FUNCTIONAL
DESCRIPTION:

Normally, the contents of XSMD are transferred into REFSMMAT at the end of MINKEY PC pulse torquing. XSMD contains the REFSMMAT computed for the stable member after torquing. Should a restart occur before the desired orientation has been achieved, however, pulse torquing stops and the XSMD-to-REFSMMAT transfer does not occur. Subject to RESTRICTIONS AND LIMITATIONS, recovery from this condition can be effected by first coarse aligning the IMU to the desired gimbal angles and then transferring XSMD into REFSMMAT via P27. Once this has been done, there are options available to the crew for obtaining a precise alignment, depending on the amount of time available and where the restart occurred (during the first or second pulse torquing).

ASSUMPTIONS:

Spacecraft orientation when coarse alignment angles were computed in P52 can be reestablished.

NOTE. — The easiest way of satisfying this requirement is by maintaining SCS attitude hold (minimum deadband) throughout the plane-change alignments.

RESTRICTIONS
AND LIMITATIONS:

1. See ASSUMPTIONS.
2. If a precise alignment is not performed before the burn, there could be a platform misalignment of as much as 1-2 deg, which could cause an error in the burn and the post-burn state vector. The in-plane velocity error for a 2-deg misalignment and a Δv of 100 ft/sec can be as much as 3.5 ft/sec, and the out-of-plane velocity error can be as much as 0.1 ft/sec.

PROCEDURES:

When restart occurs, FL VERB 50 NOUN 25 (R1, 00020) will reappear on the DSKY.

NOTE.—REFSMMAT contains the original (pre-torquing) basic-reference to stable member matrix. XSMD contains the desired (post-torquing) matrix.

1. Key VERB 41 NOUN 20 ENTR.
2. Observe FL VERB 21 NOUN 22

NOTE1.—NOUN 22 already contains the desired gimbal angles computed before the pulse torquing started.

NOTE2.—Spacecraft attitude should be as close to pre-pulse-torquing attitude as possible.

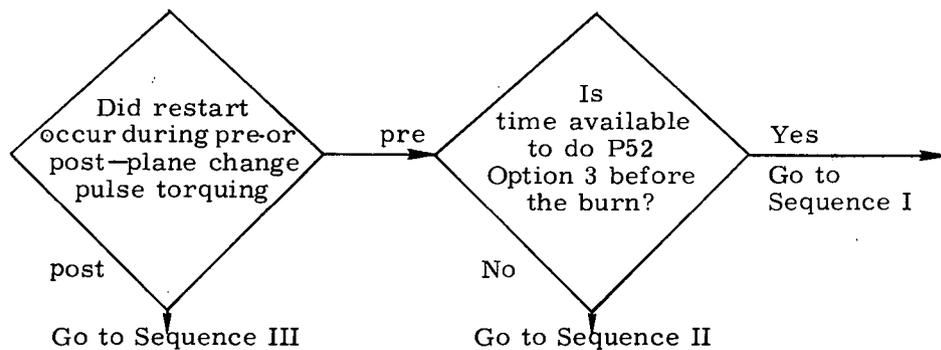
3. Key VERB 33 ENTR to coarse align to desired plane-change gimbal angles.
4. Observe VERB 41 on DSKY and NO ATT light on. Wait for return of FL VERB 50 NOUN 25 (R1, 00020).
5. Key VERB 40 ENTR to zero CDUs; observe NO ATT light off.
6. To change MODREG to zero to allow P27, key

VERB 21 NOUN 1 ENTR
1214 ENTR
ENTR

- Transfer 18 registers of XSMD into REFSMMAT as follows:

VERB 71 ENTR (observe 27 in PROG registers)
24 ENTR
1733 ENTR
VERB 21 ENTR
303 ENTR
24 ENTR
VERB 33 ENTR (observe 00 in PROG registers, although P52 is still the major mode)

- In response to FL VERB 50 NOUN 25 (R1, 00020), key PRO to continue in MINKEY sequence.
- Choose Sequence I, II, or III below.



SEQUENCE I: STAR ALIGNMENT BEFORE BURN. (RESTART DURING PRE-PLANE CHANGE PULSE TORQUING.)

- At the first display in P40/P41 (entered automatically by MINKEY), key VERB 37 ENTR 52 ENTR and perform P52 Option 3 for a precise alignment.
- At the completion of P52, key VERB 37 ENTR 40/41 ENTR to reselect P40/P41.
- If LM performed the burn, key VERB 37 ENTR 76 ENTR and perform P76.
- Execute EMP 520 to perform maneuver to track attitude and pulse torquing -45 deg and continue in MINKEY sequence.

SEQUENCE II: NO STAR ALIGNMENT BEFORE BURN. (RESTART DURING PRE-PLANE CHANGE PULSE TORQUING.)

10. Continue in MINKEY sequence to the FL VERB 50 NOUN 25 (R1, 00020) display in the post-plane change P52.
11. Key VERB 37 ENTR 52 ENTR to select P52.
12. Perform P52 Option 1 alignment to XSMD.
13. At the completion of P52 (FL VERB 37), key 33 ENTR to reselect MINKEY.

SEQUENCE III: RESTART DURING POST-PLANE CHANGE PULSE TORQUING.

10. Upon MINKEY entrance to P33, key VERB 37 ENTR 52 ENTR and perform P52 Option 3 to obtain a precise alignment.
11. At the completion of P52 (FL VERB 37), key 33 ENTR to reselect MINKEY.

RECOVERY/
TERMINATION: NA

ERASABLE
MEMORY: NA

UPLINK: NA

EMP 520: ENTRANCE INTO MINKEY FOR POST-PLANE-
CHANGE PULSE TORQUING

PURPOSE: EMP 520 provides a means of entering the MINKEY sequence to perform the -45-deg post-plane-change pulse torquing should the MINKEY sequence be interrupted at any point after the +45-deg pre-plane-change pulse torquing. This EMP is also used in conjunction with Sequence I of EMP 518.

FUNCTIONAL DESCRIPTION: AUTOSEQ flag is set to establish MINKEY sequencing; PCFLAG is reset to indicate second call to P52 for plane-change pulse torquing; and VERB 30 ENTR transfers control to the MINKEY sequence at the second call to P52.

ASSUMPTIONS: The MINKEY sequence has been interrupted at some point after the +45-deg pulse torquing.

RESTRICTIONS AND LIMITATIONS: NA

PROCEDURES:

1. Key VERB 37 ENTR 20 ENTR. Reselect option 4 if P20 has been permanently terminated or if 20 is in the PROG registers. (FL VERB 04 NOUN 06 will be displayed.)
2. Perform maneuver to track attitude if necessary (FL VERB 50 NOUN 18 will be displayed.)
3. To set AUTOSEQ (FLGWRD10, BIT 7), key

VERB 25 NOUN 7 ENTR
106 ENTR
100 ENTR
1 ENTR

4. To clear PCFLAG (FLGWRD10, BIT 1), key

VERB 25 NOUN 7 ENTR
106 ENTR
1 ENTR
ENTR

5. To load NOUN 26, key

VERB 25 NOUN 26 ENTR

13001 ENTR

2632 ENTR

10006 ENTR

} fixed-memory address of P86CONT +4

6. To select MINKEY, key

VERB 30 ENTR

7. Observe P52 in PROG registers. P52 will be entered automatically to perform pulse torquing -45 deg.
8. P52 is started at the normal MINKEY entry point, and nominal procedures should be exercised.

RECOVERY/
TERMINATION:

NA

ERASABLE
MEMORY:

NA

UPLINK:

NA

EMP 521: ENTER P51/P53 WITH IMU-
OPERATE BIT FAILED OFF

PURPOSE:

EMP 521 provides a means of entering the IMU Orientation Determination Program (P51), or its backup (P53), when the IMU-operate bit has failed in the off state. (Channel 30, Bit 9 = 1.)

NOTE.—To perform REFSMMAT determination (P51/P53) with unusable IMU, use EMP 503.

FUNCTIONAL
DESCRIPTION:

EMP 521 bypasses only the very first part of P51/P53 (see Figure: EMP 521), that part which determines whether the IMU is on and operating (bit 9 of IMODES30).

ASSUMPTIONS:

1. IMU is inertial.
2. CDUs reflect vehicle attitude with respect to IMU.

RESTRICTIONS
AND LIMITATIONS:

DAP- and IMU-failure warnings are inhibited.

PROCEDURES:

To initiate EMP 521, perform the following:

1. Key VERB 96 ENTR to clear all program activity.
2. To set MODREG to decimal 51 , key—

VERB 21 NOUN 1 ENTR
1214 ENTR
63 ENTR

to set MODREG to decimal 53 , key—

VERB 21 NOUN 1 ENTR
1214 ENTR
65 ENTR

3. Key—

VERB 25 NOUN 26 ENTR
13001 ENTR
3425 ENTR } fixed-memory address
30005 ENTR } of P51AA

to set up for the call to P51/P53 bypassing IMU-on check.

4. Key VERB 30 ENTR to start EMP 521 (and P51/P53).
5. Perform normal P51/P53 star sightings and procedure.

NOTE.—P51/P53 is activated when VERB 30 is selected in step 4, but the PROG registers will remain at 00 rather than displaying 51/53.

RECOVERY/
TERMINATION:

Normal P51/P53 restart and termination procedures.

ERASABLE
MEMORY:

NA

UPLINK:

NA

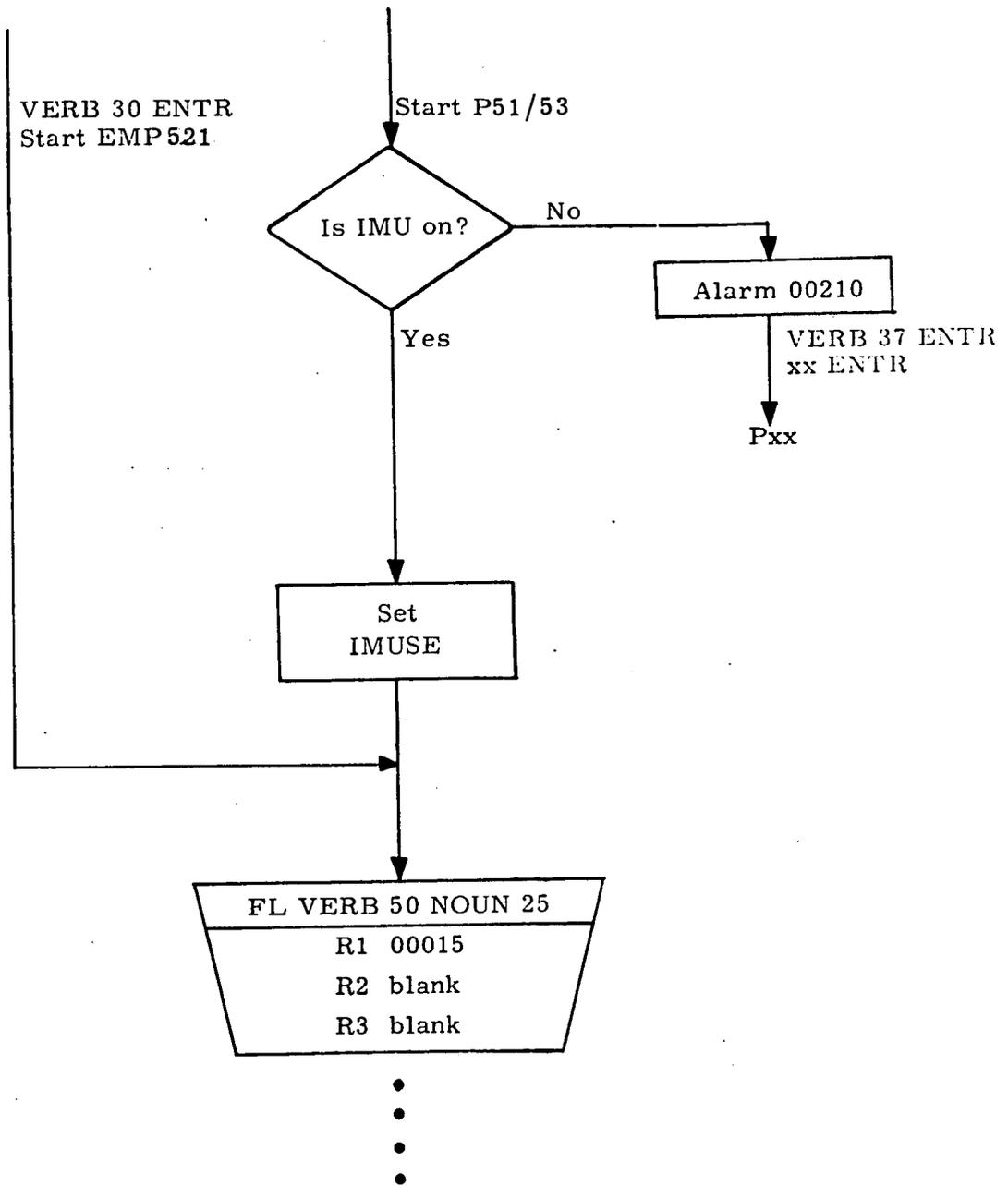


FIG: EMP 521

EMP 522: SPS GIMBAL DRIVE TEST

PURPOSE: This EMP permits the SPS Gimbal Drive Test to be performed without calling P40.

FUNCTIONAL DESCRIPTION: After loading certain erasables and NOUN 26 through the DSKY (see PROCEDURES), the crew calls EMP 522 via VERB 31 ENTR. The existing SPS Gimbal Drive Test Routine (S40.6) in P40 is immediately executed as a task. (See Figure 3.3.1 of R-577, Section 3 GSOP, Revision 14.)

ASSUMPTIONS: 1. Valid SPS engine-bell trim angles have been loaded via R03.
2. Checklist procedures for SPS engine gimbal use have been performed.

RESTRICTIONS AND LIMITATIONS: This EMP should not be performed while in P40.

PROCEDURES: 1. To initialize erasable locations MRKRTMP and CNTR, key—

VERB 25 NOUN 1 ENTR

3044 ENTR

1 ENTR

ENTR

ENTR

2. Key VERB 25 NOUN 26 ENTR

1 ENTR

2366 ENTR

40066 ENTR

} fixed-memory address of S40.6

3. Key VERB 31 ENTR to call EMP 522.

4. Monitor Gimbal Drive Sequence by reference to analog dials.

RECOVERY/
TERMINATION:

1. EMP 522 is not restart protected. If restart occurs during operation of EMP, redo steps 1, 3, and 4 of PROCEDURES.
2. EMP 522 is terminated upon completion of gimbal drive test.

ERASABLE
MEMORY:

NA

UPLINK:

NA

EMP 523: MONITOR JET-ON FAILURE

PURPOSE: EMP 523 provides a means of monitoring for jet-on failures and of activating the MASTER ALARM if a failure is detected.

FUNCTIONAL DESCRIPTION: The DAP attitude errors are monitored once per second. If any error exceeds the DAP deadband (ADB) by more than a specified amount, the ISS warning (Channel 11 Bit 1) is turned on. The ISS warning activates the MASTER ALARM. The erasable cell VHFCNT is zeroed at the start of EMP 523 and incremented each pass to provide an indication to the ground that EMP 523 is active.

NOTE.—The cell -XDEG (ECADR 644) is to be loaded as the negative of the desired allowable excursion beyond the deadband. It is scaled B-1 rev. The value shown in this document is equivalent to approximately 1 degree.

ASSUMPTIONS:

1. Program coding has been uplinked.
2. CMC mode is AUTO or HOLD and the RCS DAP is active.

RESTRICTIONS AND LIMITATIONS:

1. If any VERB 37 major mode change has been executed after EMP 523 coding is uplinked, VAC area 4 should be checked to ensure that the program code is intact.
2. EMP 523 operation does not survive a VERB 37 ENTR xx ENTR. It can be reselected (subject to RESTRICTION 1) via VERB 31 ENTR.
3. EMP 523 uses the same restart group as AVERAGEG and, therefore, should not be active during AVERAGEG.
4. EMP 523 should not be selected during P23 or P24 because of conflicting use of VHFCNT.
5. VHF marks must not be taken (Do not do VERB 87 during P20 options 0 or 4; do VERB 88 during MINKEY).

PROCEDURES:

1. The following preliminary procedures should be accomplished before executing EMP 523:

- a. CMC MODE—AUTO or HOLD
- b. SC CONT—CMC
- c. Turn on RCS DAP

2. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 523:

R1 00001
R2 00605
R3 00006

3. Key VERB 31 ENTR to call EMP 523.
4. Key VERB 16 NOUN 45 ENTR to verify operation of EMP 523:

R1 xxByy where xx should be
counting up to indicate
EMP 523 active.

RECOVERY/
TERMINATION:

1. If the MASTER ALARM has been activated by this EMP, reset as follows:
 - a. To reset Channel 11 Bit 1 (ISS Warning), key
VERB 25 NOUN 7 ENTR
11 ENTR
1 ENTR
ENTR
 - b. Press to reset MASTER ALARM light.

NOTE. —Bit 1 of Channel 11 will continually be set by EMP 523 as long as the attitude error exceeds the specified amount.

2. EMP 523 is restart protected.
3. EMP 523 is terminated by VERB 37 ENTR xx ENTR.
4. If it is desired to terminate EMP 523 during P20 without interrupting P20 tracking, the recommended procedure is to key
VERB 37 ENTR 30 ENTR
VERB 37 ENTR 20 ENTR

ERASABLE
MEMORY:

Program coding for EMP 523 is as follows:

<u>ECADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>	
604		OCT	0	00000
605	JETCHECK	CA	7	30007
606		TS	VHFCNT	54771
607		TC	PHASCHNG	05402
610		OCT	05015	05015
611		OCT	77777	77777
612		CA	7	30007
613		TS	VAC4USE	54604
614	RECHECK	CS	ADB	41655
615		AD	-XDEG	60644
616		TS	L	54001
617		CA	TWO	34767
620	XSCHECK	TS	JETINDEX	54645
621		INDEX	JETINDEX	50645
622		CCS	ERRORX	11567
623		TC	+2	00625
624		TC	LOOPEND	00632
625		AD	L	60001
626		CCS	A	10000
627		TC	DINGDONG	00640
630		TC	LOOPEND	00632
631		TC	LOOPEND	00632
632	LOOPEND	CCS	JETINDEX	10645
633		TC	XSCHECK	00620
634	NOBELL	INCR	VHFCNT	24771
635		TC	FIXDELAY	05255
636		DEC	100	00144
637		TC	RECHECK	00614
640	DINGDONG	CAF	BIT1	34770
641		EXTEND		00006
642		WOR	DSALMOUT	05011
643		TC	NOBELL	00634
644	-XDEG	OCT	77643	77643*
645	JETINDEX	OCT	0	00000

*This octal value represents approximately 1 degree.

UPLINK:

Uplink for loading EMP 523 code by P27 is as follows:

<u>Load 1</u>	<u>Load 2</u>	<u>Load 3</u>
V71E	V71E	V71E
24E	21E	5E
604E	626E	1016E
E	10000E	1E
30007E	640E	605E
54771E	632E	6E
5402E	632E	V33E
5015E	10645E	
77777E	620E	
30007E	24771E	
54604E	5255E	
41655E	144E	
60644E	614E	
54001E	34770E	
34767E	6E	
54645E	5011E	
50645E	634E	
11567E	*77643E	
625E	V33E	
632E		
60001E		
V33E		

*This octal value represents 1 degree.

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